Equipment for pediatric endoscopy

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used by performing a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (U.S. Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported complications of a given technology. Both are supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but in many cases, data from randomized, controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors.

Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the governing board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through June 2011 for articles related to endoscopy in pediatric patients by using the key words pediatric, children, infants, endoscopy, colonoscopy, gastrointestinal bleeding, single balloon enteroscopy, double balloon enteroscopy, capsule endoscopy, biopsy, esophageal strictures, dilation, endoscopic ultrasound, and ERCP.

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0016-5107/$36.00
doi:10.1016/j.gie.2012.02.023

BACKGROUND

Although pediatric endoscopy is usually performed by pediatric gastroenterologists, surgeons or adult gastroenterologists may be consulted for advanced or therapeutic endoscopy in pediatric patients. Knowledge of the equipment available for use in smaller patients, primarily those weighing less than 10 to 15 kg, is required. This report provides an overview of equipment and devices suitable for use in the endoscopic evaluation and treatment of pediatric patients.

TECHNICAL CONSIDERATIONS

Although techniques used to perform endoscopic procedures in children are essentially identical to those used in adult patients, several anatomic considerations should be noted. The newborn esophagus measures 8 to 10 cm in length and approximately 5 mm in diameter,[1] and the soft posterior wall of the trachea is easily compressed during upper GI endoscopy. Also, the antrum in small children is acutely angulated, requiring a greater degree of tip deflection to view the pylorus. The proximal duodenum is acutely angulated as well, obscuring views of the posteromedial wall.[2] The diameter of the empty duodenum, jejunum, and ileum in newborns measure 10 to 15 mm. The newborn colonic diameter is approximately 10 mm except for the cecum, which is approximately 17 mm.[1] There are no published data to guide recommendations for endoscope choice, and decisions are made based on experience and standard practice (Table 1).

EGD

Indications for diagnostic and therapeutic EGD in pediatric patients are similar to those for adults.[3] Endoscopes for pediatric cases are chosen based on the age and weight of the patient and the indication for the procedure (Table 2). Most pediatric gastroenterologists attempt endoscopy using small-caliber instruments, and if the endoscope is too small for the indication (eg, bleeding), an attempt can be made with a larger caliber instrument. The limiting factors for the use of larger gastroscopes are the inability to pass the upper esophageal sphincter or the pylorus and tracheal compression, which can occur even with an endotracheal tube in place.

TABLE 1. Endoscope choice based on weight

Weight, kg	EGD	Colonoscopy	ERCP
<2.5	≤6-mm gastroscope	≤6-mm gastroscope	7.5-mm duodenoscope
2.5-10	≤6-mm gastroscope preferred, especially in those weighing <5 kg. Standard adult gastroscope may be considered, particularly if endotherapy required	≤6-mm gastroscope or standard adult gastroscope may be safely used in those weighing 5-12 kg. Pentax 9.6-mm colonoscope not yet evaluated	7.5-mm duodenoscope
>10	Standard adult gastroscope; will likely tolerate therapeutic gastroscope if endotherapy required	11- to 11.6-mm pediatric colonoscope or adult colonoscope	Most children weighing >10 kg will tolerate standard therapeutic duodenoscope

TABLE 2. Neonatal (ultrathin) and pediatric gastroscopes

Manufacturer	Model	Insertion tube length/diameter, mm	Definition/magnification/ color enhancement	Biopsy channel/ diameter, mm
Olympus	GIF-N180	1100/4.9	Standard/none/NBI	1/2.0
	GIF-XP180N	1100/5.5	Standard/none/NBI	1/2.0
Fujinon	EG530N	1100/5.9	High-definition/zoom/	1/2.0
	EG530NP	1100/4.9	High-definition/zoom/	1/2.0
Pentax	EG1690K	1100/5.4	Standard/zoom/iSCAN	1/2.0
	EG 1870K	1050/6.0	Standard/zoom/iSCAN	1/2.0

NBI, Narrow-band imaging.

In most pediatric patients older than 12 months or in patients weighing more than 10 to 15 kg, gastroscopes with an outer diameter (OD) of 8 mm or larger may be used. For upper endoscopy in children weighing less than 10 to 15 kg, gastroscopes with an OD of 4.9 to 6.0 mm (ultrathin) are preferred, particularly for those weighing less than 5 kg.[4,5] For therapeutic cases, use of a larger gastroscope may be required, but passage may not be feasible in the smallest patients. Therapeutic gastroscopes (OD, 10.9-12.9 mm) should usually be avoided in children weighing less than 10 to 15 kg because of the risk of mucosal injury, perforation, and tracheal compression.[5]

Ultrathin (neonatal) gastroscopes are similar in design to standard gastroscopes, although some models have only 2-way (up/down) tip deflection.[6] When using these gastroscopes, right/left visualization is achieved by applying torque to the shaft of the instrument. Although the working length is identical to that of standard adult gastroscopes, the insertion tube (shaft) diameter is smaller to accommodate narrow pediatric lumens. The working channel of these gastroscopes is 1.5 to 2.0 mm, requiring small-caliber accessories. The suction capabilities may not be adequate for cases of bleeding because of the small caliber of the accessory channel, and a larger endoscope may be required for successful therapy.

COLONOSCOPY

Colonoscopy is routinely performed in infants and children in the evaluation and treatment of diarrhea, weight loss, abdominal pain, and unexplained iron deficiency anemia or rectal bleeding.[3] Pediatric colonoscopes have variable insertion tube lengths (1330-1700 mm), shaft diameters (9.8-11.8 mm), and channel size (2.8-3.8 mm) (Table 3). Pediatric colonoscopes with a shaft that can be stiffened as needed are also available (Olympus Medical Systems, Center Valley, Pa). These variable-stiffness colonoscopes were designed to improve the ease of insertion by reducing looping in more mobile sections of bowel with the ability to maintain flexibility in more fixed sections.

There are no published data to support colonoscope choice in children, but recommendations based on experience state that the lower weight limit for use of a standard adult or pediatric colonoscope is 12 to 15 kg.[7] In children weighing between 5 and 12 kg, colonoscopy can be performed by using infant or standard adult gastroscopes. Children weighing less than 5 kg may undergo successful ileocolonoscopy with ultrathin gastroscopes, although this can be technically challenging because of the flexibility of the insertion tube. Pediatric colonoscopes

TABLE 3. Pediatric colonoscopes

Manufacturer	Model	Insertion tube length/diameter, mm	Definition/magnification/color enhancement	Biopsy channel no./diameter, mm
Olympus	PCF Q180 AL	1680/11.5	High-resolution/none/NBI	1/3.2
	PCF Q180 AI	1330/11.5	High-resolution/none/NBI	1/3.2
	PCF-H180AL	1680/11.8	High-definition/none/NBI	1/3.2
	PCF-H180AI	1330/11.8	High-definition/none/NBI	1/3.2
Fujinon	EC530 LS	1690/11.5	High-definition/zoom/	1/3.8
	EC450 LS5	1690/11.5	High-definition/zoom/	1/3.8
	EC450 LP5	1690/11.1	High-definition/zoom/	1/3.2
Pentax	EC2990 Li	1700/9.8	High-definition/zoom/iSCAN	1/2.8
	EC3490 Li	1700/11.6	High-definition/zoom/iSCAN	1/3.2
	EC3490 LK	1700/11.6	High-resolution/zoom/iSCAN	1/3.8

NBI, Narrow-band imaging.

with a working channel of 2.8 mm will not accommodate larger accessories (eg, jumbo biopsy forceps).

CAPSULE ENDOSCOPY

Indications for capsule endoscopy (CE) in children include evaluation of the small-bowel mucosa for evidence of Crohn's disease, occult bleeding, celiac disease, polyps, graft-versus-host disease, lymphangiectasia, and disease contributing to growth failure or abdominal pain.[8-24] Capsule endoscopy is approved by the U.S. Food and Drug Administration in children 2 years of age and older. Video capsules measure 11 $\times$ 26 mm. The primary limitations of performance of CE in pediatric patients include the inability to swallow the capsule or tolerate placement because of the inability to pass the upper esophageal sphincter or pylorus. A capsule retention rate of 1.4% was reported in a large series of 207 pediatric patients,[25] which is similar to the rate in adults. There are no guidelines regarding the absolute lower limit of size for children with CE. A single case report was published on successful use of the capsule in a 10-month-old infant weighing 11.5 kg.[26] In patients unable to swallow the capsule, endoscopic placement in the duodenum can be performed using retrieval nets, snares, or dedicated capsule placement devices (US Endoscopy, Mentor, Ohio, and Given Imaging, Duluth, Ga).[9,27,28] The capsule can be voluntarily ingested by children as young as 6 years of age. However, success depends more on the maturity level and confidence of the child than chronologic age because many older children and teenagers fail or refuse to attempt to swallow the capsule.[29]

SMALL-BOWEL ENTEROSCOPY

Enteroscopy is performed for evaluation and therapy of the small bowel. Factors influencing choice of endoscope are similar to those listed for upper endoscopy, including tracheal compression and passage of the upper esophageal sphincter and pylorus. Performance of enteroscopy may be more challenging in pediatric patients because of the smaller abdominal cavity.

Push enteroscopy can be performed using an enteroscope or pediatric colonoscope and has been reported in children as young as 2 years of age.[30] Enteroscopes are available with an OD of 8.5 to 11.6 mm, working lengths of 2000 to 2200 mm, and a channel size of 2.2 to 3.8 mm.

Antegrade and retrograde balloon-assisted enteroscopy has been performed in children as young as 3 to 4 years of age.[31-35] Double-balloon enteroscopes (Fujinon, Wayne, NJ) have working lengths of 1520 to 2000 mm, ODs of 8.5 to 9.4 mm, and channel size of 2.2 to 2.8 mm. The required overtubes for these enteroscopes measure 12.2 to 13.2 mm in OD. Devices with adequate length for an enteroscope are available for use through a 2.2-mm channel, including argon plasma coagulation probes, biopsy forceps, and polypectomy snares. There are no guidelines on what size child may undergo double-balloon enteroscopy.

Single-balloon enteroscopy has also been performed in pediatric populations.[36] The smallest child reported to undergo an antegrade study was 3 years old and weighed 13.5 kg.[37] One single-balloon enteroscope system is available (Olympus Medical Systems) with a 9.2-mm OD, a working length of 2000 mm, and a 2.8-mm channel. An overtube is required, with a 13.2-mm OD. As in double-balloon enteroscopy, single-balloon enteroscopy can be

TABLE 4. Accessories for endoscopes with a 2-mm channel

Device	Manufacturer	Comments
Injection needles	Boston Scientific, ConMed, Cook Medical, Hobbs Medical, Mediglobe, Olympus, Telemed	22-25 g, 4-6 mm needle length
Biopsy forceps	Boston Scientific, ConMed, Cook Medical, Hobbs Medical, Kimberly Clark, Mediglobe, Micro-Tech, Olympus, Telemed, U.S. Endoscopy	Multiple cup designs, with or without needle-spike, single use or reusable
Polypectomy snare	Boston Scientific, Hobbs Medical, Kimberly Clark, Olympus, Telemed	≤30-mm diameter
ERCP cannulation catheters	Boston Scientific, ConMed, Mediglobe, Telemed	Curved, straight, or tapered tip, 0.018-0.035 wire
Sphincterotomes	Cook Medical, Mediglobe, Olympus	Limited to double lumen, cannot take 0.035 wire
Needle-knife papillotome	Cook Medical, Mediglobe, Olympus	
Stone retrieval balloons	Boston Scientific, Horizons International, Mediglobe, Olympus	
Retrieval baskets	Hobbs Medical, Horizons International, Kimberly Clark, Mediglobe, Olympus, Telemed	3- or 4-wire, 10-30-mm diameter
Graspers and retrieval devices	Endochoice, Hobbs Medical, Kimberly Clark, Olympus, Telemed, U.S. Endoscopy	3- or 4-prong, alligator jaw, rat-tooth, single use or reusable, Roth Net
Bipolar probe	ConMed	200 cm
Argon plasma coagulation probe	ConMed, ERBE, U.S. Medical Innovation	ERBE offers 300-cm probe

performed in any child able to tolerate the diameter of the overtube.

Spiral enteroscopy (Olympus Medical Systems) has not been reported in children, and the combined 16-mm diameter of the overtube and spiral apparatus currently makes this technique impractical for most pediatric patients.[29]

ERCP

ERCP is routinely performed in infants and children for primarily therapeutic indications (eg, biliary obstruction, pancreatic disease, ductal leaks).[38-46] Cannulation rates are similar to those of adult series at experienced centers.[39,40,47] Pediatric duodenoscopes (OD, 7.5-7.6 mm; working channel, 2 mm) are available. Most children older than 12 months of age or weighing more than 10 to 15 kg can tolerate a standard adult diagnostic or therapeutic duodenoscope (OD, 10.8-12.1 mm), although the soft-walled trachea in young children may become compressed because of the large diameter.[48-50]

EUS

No pediatric-specific equipment has been produced for the performance of EUS in children, and there are limited data on the use of EUS in this population. Standard adult radial echoendoscopes have a tip diameter ranging from 12.7 to 14.2 mm; linear FNA echoendoscopes are slightly larger, measuring 12.1 to 14.6 mm in tip diameter.[51] Use of the larger echoendoscopes should be limited to pediatric patients weighing at least 15 kg, and caution should be used, given their relatively rigid distal tip. Through-the-scope miniprobes with frequencies ranging from 12 to 30 MHz may be used through standard gastroscopes with a 2.8-mm working channel. These miniprobes have been used in infants as young as 5 months of age.[52,53] In smaller infants requiring an ultrathin gastroscope, a 1.7-mm OD miniprobe is available.

DEVICES FOR USE WITH PEDIATRIC ENDOSCOPES

In pediatric endoscopy, the size of the working channel of the chosen endoscope is the main factor limiting the choice of accessories. Multiple devices are available for use through endoscopes with 2-mm channel (Table 4).

Biopsy forceps

Mucosal biopsies are an essential component of most pediatric endoscopic procedures. Forceps that fit through a 2-mm channel are available in fenestrated and serrated designs, with and without a needle-spike and with oval or alligator-type cups. Hot biopsy forceps are not available for use with a 2-mm channel. Large-cup forceps, which allow for a sample 2 to 3 times larger than standard forceps, have been used in children without complications,[54] but the utility of a larger tissue specimen is uncertain in the pediatric population. Biopsy forceps fitting through a 2-mm channel are available from multiple manufacturers (Table 4).

Polypectomy devices

Most children requiring polypectomy are large enough to tolerate an endoscope with a 2.8-mm channel, enabling the use of standard adult polypectomy snares. Nonetheless, polypectomy snares for use through a 2.0-mm channel are available.

Endoscopic retrieval devices

Devices used for foreign-body retrieval are available for use through 2-mm channels. These include retrieval snares, retrieval nets, alligator jaw, rat-tooth, and 3-prong graspers, as well as baskets. Use of these various devices is detailed in a previous report.[55] There are no published data on the use of overtubes in pediatric patients, and they are rarely used because their relatively large diameter poses an increased risk of trauma to the esophagus or pharynx.[2] As in adults, retrieval hoods can be used in pediatric patients. However, they do not fit on ultrathin endoscopes.

Hemostatic devices

Commonly used hemostatic techniques for nonvariceal GI bleeding in children include injection therapy, mechanical closure, and thermal techniques such as multipolar/bipolar electrocautery, heater probe, and argon plasma coagulation. Use of these devices in children is similar to use in adults, and no modifications are made in technique, although argon gas may need to be suctioned more frequently in small children because of distention of the stomach or bowel.[56] Patient return electrodes, or grounding pads, are available in neonatal ($<$3 kg), pediatric ($<$15 kg), and adult sizes. Adjustments must be made based on the channel diameter of the gastroscopes needed for smaller children. For instance, because no endoscopic clipping devices are produced to fit through a 2.0-mm channel, this technique is not available for children weighing less than 3 to 4 kg who cannot tolerate a standard gastroscope. Variceal band ligation devices will not fit on a pediatric or ultrathin endoscope. The other limiting factor to using a band ligation device in children is whether the loaded apparatus can be passed through the pharynx, which cannot be predicted by weight or age alone.[57] Variceal band ligation traditionally has not been possible in children weighing less than 10 to 15 kg because of the diameter of the banding device, although smaller banding devices are available with a tip OD of 8.5 to 9.2 mm (Cook Endoscopy, Winston-Salem, NC). Published series report successful variceal band ligation in children, with the youngest ranging from 1 to 4 years of age.[57-63]

Injection needles, multipolar/bipolar electrocautery probes, and argon plasma coagulation probes are all available in sizes small enough to pass through a 2-mm channel for use in infants too small to tolerate a standard gastroscope.

Therapy for esophageal strictures

Dilation of esophageal strictures in pediatric patients has been performed for decades.[64-73] Through-the-scope balloon dilation is possible in larger infants and children, but there are no dilation balloons that fit through a 2-mm channel. Balloon dilation can be performed in infants who will not tolerate a standard gastroscope by using a guidewire and over-the-wire dilation balloons (eg, biliary dilation balloons) under fluoroscopic guidance.[72,74] Biliary dilation balloons are available in sizes ranging from 4 to 10 mm with lengths from 2 to 8 cm and can be used with endoscopically placed 0.035-inch guidewires.

Bougie dilators can be passed across esophageal strictures by applying axial and radial force to the narrowed region.[75] Available bougie dilators include Savary-Gilliard (Cook Endoscopy), American Dilation System (C.R. Bard, Inc, Billerica, Mass), Maloney (Medovations, Milwaukee, Wisc), Hurst dilator (Medovations, Milwaukee, Wisc), and Tucker dilator (Teleflex Medical, Research Triangle Park, NC). Savary-Gilliard dilators are tapered with a radiopaque marker at the base of the taper. These polyvinyl wire–guided dilators have various diameters (5-20 mm or 15F-60F) and lengths (70 or 100 cm). American Dilation System dilators are similar but have a shorter taper tip and are radiopaque throughout their length. Tungsten-weighted bougies include Maloney and Hurst dilators, which are tapered or blunt tipped, respectively, range in size from 5.3 to 20 mm (16F-60F), and are passed antegrade without a guidewire. Tucker dilators are especially useful in the treatment of tortuous strictures secondary to caustic ingestions.[76,77] These are small silicone bougies, tapered at each end with loops that can be pulled antegrade or retrograde across very tight strictures regardless of length. A gastrostomy is required for use. In very tight strictures where there is the possibility of complete lumen occlusion, a string must be maintained across the stricture emerging from both the nose and gastrostomy site between dilations. Tucker dilators range in size from 4 to 13.3 mm (12F-40F).

There are no esophageal stents designed for pediatric use. The use of plastic and nitinol esophageal and airway stents has been reported in treating recalcitrant esophageal strictures in children in case series.[78-81] The smaller diameter (10-20 mm) and shorter length (20-80 mm) of the airway stents may make them more suitable in smaller patients. The choice of a particular stent must be based on the location and characteristics of the stricture as well as the size of the patient.

Pneumatic dilation for treatment of achalasia in children is successfully performed.[82-88] Pediatric-specific pneumatic dilation balloons are not produced, and standard 30-, 35-, and 40-mm polyurethane balloons are used.

Devices for use in ERCP

Use of an adult duodenoscope is desirable when performing biliary or pancreatic therapy. Cannulas and sphincterotomes designed for the smaller working channel of pediatric duodenoscopes have only a single lumen for either guidewire or contrast use. These devices accept 0.018- or 0.021-inch guidewires. Stone retrieval balloons and baskets for use with a 2-mm channel are commercially available. Biliary dilation balloons and stents greater than 5F will not fit through a 2-mm channel.

EFFICACY AND COMPARATIVE STUDIES

Minimal data exist that compare endoscopic equipment and techniques in children, and pediatric publications are typically retrospective case series. Results of adult studies are the primary guidelines used to evaluate equipment for pediatric endoscopy.

Therapeutic endoscopy is required less frequently in the pediatric compared with the adult population. Endoscopic hemostatic techniques are performed by pediatric gastroenterologists but have not been prospectively studied in children.[56] Sclerotherapy of esophageal varices has been shown to be effective but not superior to endoscopic variceal ligation in infants and children[89-92] and is associated with more complications such as esophageal ulceration and stricture.[57,59,61,63,93-95] Data are mixed regarding the efficacy of wire-guided bougie dilators compared with balloon dilators in the treatment of esophageal strictures, and safety appears to be comparable.[96,97] Pneumatic dilation for achalasia has been compared with surgical myotomy in several small reviews.[82-88] Most conclude that surgery offers a more durable benefit, but pneumatic dilation is effective and is a reasonable first-line therapy in children. Argon plasma coagulation using a 2.3- or 1.5-mm probe was used in a series of 13 pediatric patients, mainly for bleeding (n = 12) indications (eg, ulcers, hemangioma, eroding tumor mass).[98] Argon flow was kept constant at 0.9 L/min and power at 55 W. Hemostasis was achieved in 8 of 12 patients with 1 session, and blood loss was reduced in 3 of the other 4.

A number of small series examined the use of CE in children, particularly when inflammatory bowel disease (IBD) is suspected.[8,10-13,24,26,99] Retrospective studies have shown that CE is valuable in revealing previously undetected small-bowel inflammation in children with IBD[99] and may lead to reclassification of IBD from ulcerative colitis or IBD unclassified to definitive Crohn's disease.[13] A retrospective comparison of CE with barium enterography found that CE was superior in the identification of small-bowel polyps measuring less than 10 mm in children with Peutz-Jegher syndrome, but there was no difference in the detection of polyps larger than 10 mm.[19] Additional studies have shown CE to be useful in the evaluation of pediatric patients with suspected small-bowel bleeding,[14-17] suspected celiac disease when serology and small-bowel biopsy have not confirmed the diagnosis,[100] suspected graft-versus-host disease,[101] unexplained growth failure,[21] recurrent abdominal pain,[22] and protein-losing enteropathy.[23]

Several series and case reports describe the use of covered esophageal stents in children with either caustic or anastomotic strictures.[78-80] The majority of patients (50%-85%) had a complete response without recurrence of dysphagia. A study published in abstract form reported the use of airway stents in 4 infants who had undergone surgical repair of long-gap esophageal atresia.[81] In this difficult subpopulation, symptom recurrence was common, and 94% of the cases resulted in restricturing within 14 days of stent removal.

The feasibility of pediatric ERCP has been reported in several retrospective studies.[38-45,102,103] A case-control study compared 116 children with 116 adults who had undergone 163 and 173 ERCPs, respectively.[39] Procedures were grouped by complexity, and the success rate in children was found to be 97.5% compared with 98% in the adult cohort (*P* = not significant).[39]

There have been 2 large series on the use of EUS in pediatric patients. One series reported 40 examinations in 38 children (ages 3-17 years, mean age 13.5 years) over a 7-year period at 2 centers.[104] There were various indications, including mediastinal mass (n = 5), gastric mass or polyp (n = 6), and pancreatic or biliary indications (n = 3). FNA was performed in 30% and fine-needle injection in 5%. No complications related to sedation or the procedures were reported. Another series published in abstract form of 175 EUS examinations (100 upper, 75 lower) in children age 2 months to 16 years reported complications in 2 of 76 interventional procedures (2.5%), including a mucosal tear after dilation of a Crohn's stricture and bleeding after duodenal polypectomy.[105] Successful evaluation of perianal disease by EUS has been reported in a pediatric population,[106] and therapeutic EUS has been reported in patients weighing as little as 17.5 kg.[104,107-109]

Safety

The safety of pediatric diagnostic endoscopy has been well documented in even the youngest and smallest infants.[38-45,110,111] A retrospective 4-year database study of 10,236 EGDs in children found an immediate complication rate of 2.3%, with most related to hypoxia and bleeding. Patients in the youngest age group were at the highest risk of complications.[111] Other significant patient- and procedure-related risk factors included higher American Society of Anesthesiologists class, use of intravenous sedation as opposed to general anesthesia, and the procedure being performed in the presence of a fellow.[111] Another retrospective study of 1653 procedures found a complication rate of 0.3%

including oxygen desaturation (n = 2) and gastric perforation caused by a defective guidewire (n = 1).[112] There were no deaths or episodes of cardiac arrest. Colonoscopy appears to be very safe as well. A 6-year retrospective database study of 7792 procedures found an overall complication rate of 1.1%. Slightly more than half were GI-related complications, most commonly bleeding, 30% were cardiopulmonary complications, and 10% miscellaneous (ie, drug rash). Perforation was very uncommon (0.01%).[113] Esophageal balloon dilation in children is associated with risks of bacteremia[114] and perforation. Complications associated with esophageal stent placement in children and infants are fairly common. As in adults, stent migration is common, occurring in 10% to 29% of all cases.[115] Chest pain and vomiting occurred in 8 of 8 of patients in 1 study[80] and dysphagia and respiratory distress in 29% and 14% of patients, respectively, in another.[78]

The primary risk of CE is retention, occurring in 1.4% of patients in 1 series.[25] Increased risk of retention is associated with known IBD (5.2%), IBD with a body mass index less than fifth percentile (43%), and abnormal results on a small-bowel contrast study (37.5%).[25]

Advanced and therapeutic procedures appear to be safe in the pediatric population. With the exception of a single small-bowel perforation during polypectomy in a 3-year-old child,[116] most data suggest that the use of balloon enteroscopy, even in small children, is safe.[31-37] EUS appears to be safe as well,[104,106-109,117] although the specific lower limits of size and age in which both EUS and balloon enteroscopy can be safely performed has yet to be determined. Success rates and complications of ERCP in infants and children mirror those seen in adult patients.[38-45] Although 1 pediatric paper reported a post-ERCP pancreatitis rate of 9.7%,[47] 2 other large retrospective pediatric series reported a post-ERCP pancreatitis rate of 2.5% to 3%. Interestingly, 1 study noted an increased risk of post-ERCP pancreatitis in patients with existing chronic pancreatitis.[102]

FINANCIAL CONSIDERATIONS

Indications for endoscopy requiring specific devices other than biopsy forceps designed to fit through 2-mm channels are relatively rare. Thus, purchasing these products in bulk can result in unused equipment. Vendors may be amenable to selling devices individually to pediatric endoscopy units, and at times equipment or devices can be shared by neighboring adult and/or pediatric facilities. Current Procedural Terminology codes do not distinguish between procedures performed on children or adults. However, the -63 modifier can be used to indicate complexity and increased risk associated with endoscopic procedures performed on infants weighing less than 4 kg.

AREAS FOR FUTURE RESEARCH

Few prospectively collected data exist to guide endoscopic practice in pediatric patients. Prospective studies are needed to define the most effective endoscopic methods for treating GI bleeding, esophageal strictures, and pancreatic and biliary disease in children. Studies to help define indications for therapeutic endoscopy in children are important as well. Research designed to evaluate the benefit of pediatric gastroenterologists pursuing advanced therapeutic endoscopy training is needed. Although endoscopists in high-volume adult centers have procedural expertise often lacking in pediatric gastroenterologists, the advantages of procedures being performed in dedicated pediatric centers by providers more familiar with pediatric physiology and disease process must be taken into account. The use of bariatric devices should be studied in the pediatric population, given the burgeoning epidemic of obesity in children. Studies should be performed to delineate the value of mucosal enhancement techniques (eg, electronic chromoendoscopy, magnification) in pediatric patients.

SUMMARY

Equipment necessary for diagnostic and therapeutic endoscopy in children older than 1 to 3 years of age and weighing more than 10 to 15 kg are generally identical to that used in adults. Toddlers and infants, however, require smaller endoscopes that have smaller working channels. Many devices for use with small-caliber endoscopes or through a 2-mm channel are available as listed in this document. However, accessories for treating conditions such as GI bleeding are more limited because no endoscopic clips or variceal band ligation devices are available for use with pediatric gastroscopes. Pediatric duodenoscopes are available for purchase or loan but are rarely required. A wider array of devices and accessories suitable for use in pediatric patients is desirable.

DISCLOSURE

The authors disclosed no financial relationships relevant to this publication.

Abbreviations: CE, capsule endoscopy; IBD, Residency Review Committee; OD, outer diameter.

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This document is a product of the ASGE Technology Assessment Committee. This document was reviewed and approved by the Governing Board of the ASGE.